

Nuclear effects on J/ψ production in proton-nucleus collisions

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Abstract

The study of nuclear effects for J/ψ production in proton-nucleus collisions is crucial for a correct interpretation of the J/ψ suppression patterns experimentally observed in heavy-ion collisions. By means of three representative sets of nuclear parton distributions, the energy loss effect in initial state and nuclear absorption effect in final state are taken into account in the uniform framework of the Glauber model. A leading order phenomenological analysis is performed on J/ψ production cross section ratios $R_{W/Be}(x_F)$ for the E866 experimental data. The J/ψ suppression is investigated quantitatively due to the different nuclear effects. It is shown that the energy loss effect with resulting in the suppression on $R_{W/Be}(x_F)$ is more important than the nuclear effects on parton distributions in high x_F region. The E866 data in the small x_F keep out the nuclear gluon distribution with a large anti-shadowing effect. However, the new HERA-B measurement is not in support of the anti-shadowing effect in nuclear gluon distribution. It is found that the J/ψ -nucleon inelastic cross section $\sigma_{abs}^{J/\psi}$ depends on the kinematical variable x_F , and increases as x_F in the region $x_F > 0.2$.

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I. INTRODUCTION

The production of J/ψ in high energy collisions has attracted the extensive attention from both the nuclear and particle physics communities^[1]. J/ψ suppression is considered as a most reliable signature for the formation of Quark Gluon Plasma (QGP) in heavy ion collisions during the present time. However, there are many different nuclear effects in nucleus-nucleus collisions. A robust interpretation of the experimental data in heavy ion collisions requires to understand deeply and quantitatively the basic mechanisms responsible for the suppression of J/ψ production due to the nuclear effects. Therefore, it is desirable that a good baseline should be established by means of the study on J/ψ production in proton-nucleus collisions to clarify the conventional nuclear suppression mechanism.

Several proton-induced fixed target experiments (such as, NA3^[2], E772^[3], E866^[4], NA50^[5] and HERA-B^[6]) have studied the nuclear dependence of J/ψ production cross-sections as a function of the Feynman variable x_F . These experimental measurements employ the usual parametrization by a power law: $\sigma_{pA} = \sigma_{pN} \cdot A^\alpha$, where σ_{pN} is the proton-nucleon cross section and σ_{pA} is corresponding proton-nucleus cross section for a target of atomic mass number A . The E866 collaboration^[4] published the precise measurement of the suppression factor α for 800 GeV protons incident on iron and tungsten nuclear targets, relative to beryllium nuclear targets with very broad coverage $-0.1 < x_F < 0.95$. The observed suppression is smallest at x_F values of 0.25 and below, and increases at larger values of x_F . Recently, the HERA-B collaboration^[6] reported the first measurement of nuclear effects in J/ψ production extending into the larger negative part of the Feynman- x spectrum, $-0.34 < x_F < 0.14$ by 920 GeV protons incident on carbon, titanium and tungsten targets. The E866 and HERA-B results are compatible within statistical and systematic uncertainties in the overlap region, and are systematically above the NA50 results^[5] with based on lower energy collisions. At lower values of x_F , the HERA-B $\alpha(x_F)$ measurement indicates a reversal of the suppression trend seen at high x_F : the strong suppression established by previous measurements at high x_F turns into a slight tendency towards enhancement in the negative x_F region.

It is now clear that J/ψ production occurs in two different steps where a charm quark pair is produced first through the interaction of a projectile on a target parton, followed by the non-perturbative formation of the colorless asymptotic state. As a consequence, color

octet as well as singlet $c\bar{c}$ states contribute to J/ψ production. Two formalisms have been proposed to incorporate these features, which are the non-relativistic QCD (NRQCD) [7], and the color evaporation model (CEM) [8], respectively. The CEM shows some similarities with NRQCD. In CEM calculations, J/ψ production via color-octet processes is allowed, hence the kinematic dependence of the cross section is similar to NRQCD in the production of J/ψ . The CEM and NRQCD predictions have been successful in charmonium phenomenology. Therefore, the CEM and NRQCD are used to date as a model for charmonium production. It is interesting to notice that the measured J/ψ polarization favors the CEM and is not within the predictions of NRQCD, and the CEM has fewer free parameters than NRQCD[9].

The suppression of J/ψ production in proton-nucleus collisions could be caused by many different nuclear effects. The nuclear effects are usually subdivided in "initial state effects" related to the projectiles which produce a charm quark pair and "final state effects" from interactions of the charm quark pair or the fully formation of a J/ψ in the nuclear environment. The nuclear effects on parton distribution functions and initial state energy loss effect are considered as the most important initial state effects, while the so-called nuclear absorption of the charm quark pair is the main final state effect.

After the production of a charm quark pair, the pre-meson charm quark pair will travel through the nuclear environment. They are subject to the strong interactions with the nuclear matter. Such interactions, which reduce the probability that the pre-meson state will ultimately form a J/ψ without being absorbed, can be described by the Glauber model[10]. The nuclear absorption cross section is introduced to express the J/ψ production in proton-nucleus collisions.

After the discovery of the EMC effect[11], it is well known that nuclear parton distribution functions are different from those in a free nucleon. The nuclear modifications relative to the nucleon parton distribution functions, are usually referred to as the nuclear effects on the parton distribution functions, which include nuclear shadowing, anti-shadowing, EMC effect and Fermi motion effect in different regions of parton momentum fraction. As for the nuclear parton distributions, the global analysis method has been proposed in the recent years. So far, three groups have presented global analysis of the nuclear parton distribution functions analogous to those of the free proton. These are the ones by Eskola et al. (EKS98 [12] and EPS[13]), by Hirai et al. (HKM[14], HKN04[15] and HKN07[16]), and by de Florian and Sassot (nDS) [17]. It is noticeable that the nuclear valence quark distributions from different global

analysis are nicely in good agreement. The nuclear sea quark and gluon distributions in general are still quite badly constrained, resulting in large differences between the different sets.

The initial state energy loss effect is another nuclear effect apart from the nuclear effects on the parton distribution as in deep inelastic scattering. In high energy proton-nucleus scattering, the projectile rarely retains a major fraction of its momentum in traversing the nucleus. The projectile can lose a finite fraction of its energy due to the multiple collisions and repeated energy loss in the nuclear target. The proton incident Drell-Yan reaction^[18] on nuclear targets provides, in particular, the possibility of probing the propagation of projectile through nuclear matter, with the produced lepton pair not interacting strongly with the partons in the nuclei. Therefore, the nuclear Drell-Yan process is an ideal tool to study initial state energy loss effect. At parton level, the nuclear Drell-Yan process is only sensitive to the quark energy loss^[19]. However, a charm quark pair is predominantly due to gluon fusion in proton induced J/ψ production on nuclear targets. The gluon energy loss can not yet be constrained by the experimental data though some theoretical papers^[20] on J/ψ production employ the conclusion that the gluon energy loss is 9/4 times larger than the quark energy loss due to the difference in the color factors. As a result, the initial state energy loss effect is not pinned down in J/ψ production which is predominantly due to gluon fusion.

In the previous article^[21], by using the nuclear parton distribution functions from the global analysis, the nuclear Drell-Yan production cross section ratios were investigated for 800GeV protons incident on a variety of nuclear targets in the framework of Glauber model. At hadron level, the energy loss of the beam proton in nuclear environment was determined well by fitting the nuclear Drell-Yan data from the Fermilab E866 experiment^[22]. In this paper, by combining three representative sets of nuclear parton distribution functions with the initial state energy loss of the incident proton determined by the nuclear Drell-Yan reaction, J/ψ production cross section ratios for 800GeV protons incident on tungsten and beryllium nuclear targets are analyzed with meanwhile taking account of the nuclear absorption effect in the Glauber model. It is hoped to have a new knowledge about the nuclear effects on J/ψ production in proton-nucleus collisions.

The paper is organized as follows. In sect.II, a brief formalism for the differential cross section in J/ψ production is presented. The section III is our results and discussion. The

summary is given in sect.IV.

II. THE FORMALISM FOR J/ψ PRODUCTION DIFFERENTIAL CROSS SECTION

At leading order(LO) in perturbative QCD, the charmonium production cross section is the sum of two partonic contributions, gluon fusion (gg) and quark-anti-quark annihilation ($q\bar{q}$), convoluted with the parton distribution functions in the incident proton p and the target nucleus A ^[23]:

$$\begin{aligned} \frac{d\sigma}{dx_F} = & \rho_{J/\psi} \int_{2m_c}^{2m_D} dm \frac{2m}{\sqrt{x_F^2 s + 4m^2}} \left[f_g^p(x_1, m^2) f_g^A(x_2, m^2) \sigma_{gg}(m^2) \right. \\ & \left. + \sum_{q=u,d,s} \left\{ f_q^p(x_1, m^2) f_{\bar{q}}^A(x_2, m^2) + f_{\bar{q}}^p(x_1, m^2) f_q^A(x_2, m^2) \right\} \sigma_{q\bar{q}}(m^2) \right], \end{aligned} \quad (1)$$

where $x_{1(2)}$ is the projectile proton (target) parton momentum fractions, $x_F = x_1 - x_2$, \sqrt{s} is the center of mass energy of the hadronic collision, $m^2 = x_1 x_2 s$, $m_c = 1.2\text{GeV}$ and $m_D = 1.87\text{GeV}$ are respectively the charm-quark and D meson mass, and σ_{gg} ($\sigma_{q\bar{q}}$) is the LO $c\bar{c}$ partonic production cross section from the gluon fusion(quark-antiquark annihilation). $\rho_{J/\psi}$ is the fraction of $c\bar{c}$ pair which produces the J/ψ state, f_i^p and f_i^A stand respectively for the parton distribution function in the proton and in the nucleus.

According to Glauber model^[10], the projectile proton scattering inelastically on nucleus (A) makes many collisions with nucleons bound in nuclei. The probability of having n collisions can be expressed as

$$P(n) = \frac{\int d\vec{b} P(n, \vec{b})}{\sum_{n=1}^A \int d\vec{b} P(n, \vec{b})}, \quad (2)$$

where

$$P(n, \vec{b}) = \frac{A!}{n!(A-n)!} [T(\vec{b})\sigma_{in}]^n [1 - T(\vec{b})\sigma_{in}]^{A-n},$$

$\sigma_{in}(\sim 30\text{mb})$ is non-diffractive cross section for inelastic nucleon-nucleon collision, and $T(\vec{b})$ is the thickness function of impact parameter \vec{b} .

Now let us take account of the energy loss of the projectile proton moving through the target nuclei before producing the charm quark pair in proton-nucleus. The energy loss due

to beam proton can induce the decrease of center of mass system energy of the nucleon-nucleon collision producing $c\bar{c}$, and affect the measured J/ψ production cross section. After the projectile proton has n collisions with nucleons in nuclei, it is supposed for convenient calculation that the center-of-mass system energy of the nucleon-nucleon collision can be expressed as

$$\sqrt{s'} = \sqrt{s} - (n-1)\Delta\sqrt{s}, \quad (3)$$

where $\Delta\sqrt{s}$ is the center-of-mass system energy loss per collision in the initial state (see Ref.[21] for more detail discussion). Therefore, the J/ψ production cross section in the n th collision can be rewritten as

$$\frac{d\sigma^{(n)}}{dx_F} = \frac{d\sigma}{dx'_F}. \quad (4)$$

Here the rescaled quantities are defined as

$$x'_F = r_s x_F, \quad x'_{1,2} = r_s x_{1,2}, \quad (5)$$

with the centre-of-mass system energy ratio:

$$r_s = \frac{\sqrt{s}}{\sqrt{s'}}. \quad (6)$$

Furthermore, the nuclear absorption of the charm quark pair is added in final state effect. In the framework of the Glauber model, the probability for no interaction (or “survival probability”) of the J/ψ meson with the target nucleus^[24], can be calculated as

$$S_{\text{abs}} = \frac{1}{(A-1)\sigma_{abs}^{J/\psi}} \int d\vec{b} (1 - e^{-(A-1)T(\vec{b})\sigma_{abs}^{J/\psi}}). \quad (7)$$

The survival probability depends obviously on both the atomic mass number A of the target nucleus and the J/ψ -nucleon inelastic cross section $\sigma_{abs}^{J/\psi}$. If the factorization between the $c\bar{c}$ production process and the subsequent possible J/ψ inelastic interaction with nuclear matter is assumed, the J/ψ production cross section in the n th collision is written as

$$\frac{d\sigma^{(n)}}{dx_F} = \frac{d\sigma}{dx'_F} S_{\text{abs}}. \quad (8)$$

Combining above ingredients on initial and final state effects, the J/ψ production cross section in proton-nucleus collisions can be expressed as

$$\langle \frac{d\sigma}{dx_F} \rangle = \sum_{n=1}^A P(n) \frac{d\sigma^{(n)}}{dx_F}. \quad (9)$$

III. RESULTS AND DISCUSSION

The Fermilab Experiment866(E866) ^[4] measured the differential cross section ratios of proton induced tungsten to beryllium target for J/ψ production,

$$R_{W/Be}(x_F) = \frac{\langle \frac{d\sigma^{p-W}}{dx_F} \rangle}{\langle \frac{d\sigma^{p-Be}}{dx_F} \rangle}. \quad (10)$$

The covered kinematical range was $-0.1 < x_F < 0.95$. The experimental data were provided in small x_F ($-0.1 < x_F < 0.3$), intermediate x_F ($0.2 < x_F < 0.65$), and large x_F ($0.3 < x_F < 0.95$), respectively. By using three sets of leading order nuclear parton distribution functions together with CTEQ6L parton density in the proton^[25], meanwhile taking account of the energy loss of the beam proton in initial state effect and the nuclear absorption of the charmonium states traversing the nuclear matter in the uniform framework of the Glauber model, a leading order phenomenological analysis is given in the color evaporation model to the E866 experimental data on the ratios of J/ψ production differential cross section $R_{W/Be}(x_F)$.

As for the nuclear parton distributions in our calculation, the nuclear modification for gluon distribution function is apparently different between the different sets. The Figure 1 shows the ratio of the tungsten nucleus over the proton parton distribution function at the charm quark pair mass scale, $R_g^W(x, Q^2 = (2m_c)^2)$, as a function of Bjorken x for the leading order nDS (dotted line), EKS98 (solid line) and HKN07 (dashed line) nuclear gluon distribution functions. The main differences between the three nuclear parameterizations are found that nDS and EKS98 nuclear gluon densities have respectively nuclear anti-shadowing effect in the region $0.03 < x < 0.25$ and $0.03 < x < 0.38$. It is emphasized that nDS nuclear gluon density have comparatively very small anti-shadowing than EKS98 in intermediate x region, whereas HKN07 nuclear gluon distribution function has only the nuclear shadowing effect in small x . The ratio R_g^W from HKN07 increases as x becomes larger, and crosses the line $R_g^W = 1$ at $x \sim 0.1$.

If neglecting the energy loss in initial state effect and the nuclear absorption in final state effect, the calculated results are compared with the E866 experimental data^[4] on J/ψ production cross section ratios $R_{W/Be}(x_F)$ in Fig.2. The solid, dotted and dashed lines are the results on $R_{W/Be}(x_F)$ by using the EKS98, nDS and HKN07 parameterizations, respectively. As can be seen in Fig.2, $R_{W/Be}(x_F)$ from nDS nuclear parton distributions

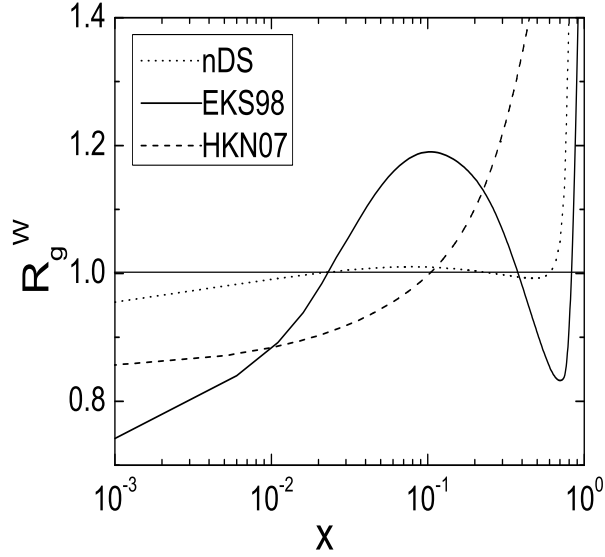


FIG. 1: The ratio R_g^W of the gluon distribution in a tungsten nucleus over that in a free proton. The solid, dotted and dashed lines correspond to the results given by the EKS98, nDS and HKN07 nuclear parton distributions, respectively.

shows a remarkably flat behavior as a function x_F in the region $|x_F| < 0.1$. However, $R_{W/Be}(x_F)$ by HKN07 parameterizations turns into a tendency towards enhancement in the negative x_F region. The anti-shadowing enhancement is appeared in the EKS98 model at $x_F \approx 0$. It is worth noting that the nuclear suppression from the nuclear effects on the parton distributions becomes larger as the increase of x_F in the range $x_F > 0$. With taking example by HKN07 nuclear parton distribution functions, the suppression is approximately 4% to 14% for $R_{W/Be}(x_F)$ in the ranges $0.1 \leq x_F \leq 0.95$.

The curves in Fig.3 show the calculated $R_{W/Be}(x_F)$ for J/ψ production, compared with the E866 data, given by using the EKS98, nDS and HKN07 nuclear parton distributions together with the energy loss of the beam proton in initial state effects. In our calculations, the center-of-mass system energy loss per collision $\Delta\sqrt{s} = 0.18\text{GeV}$ was determined from the nuclear Drell-Yan experimental data in the Glauber model^[21]. It is found that the energy loss effect of the beam proton in initial state has a small impact on the differential cross section ratios $R_{W/Be}(x_F)$ in the region $x_F < 0.2$. However, the energy loss effect adds further the nuclear suppression on $R_{W/Be}(x_F)$ in the range $x_F > 0.2$. The nuclear suppression on

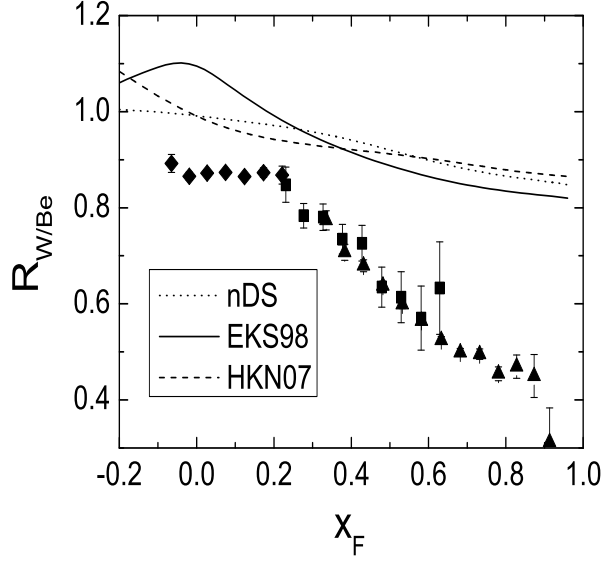


FIG. 2: The J/ψ production cross section ratio $R_{W/Be}(x_F)$. The filled diamonds (boxes and triangles) are the E866 experimental data [4] in the region $-0.1 < x_F < 0.3$ ($0.2 < x_F < 0.65$ and $0.3 < x_F < 0.95$). With assuming only the nuclear effects on the parton distribution functions, the solid, dotted and dashed lines correspond to the results from the EKS98, nDS and HKN07 parameterizations, respectively.

$R_{W/Be}(x_F)$ from energy loss effect increases gradually in the region $0.2 \leq x_F \leq 0.8$, and becomes much steeper in the region $x_F > 0.8$. The suppression due to energy loss effect is approximately 1% to 14% and 14% to 50% in the ranges $0.2 \leq x_F \leq 0.8$ and $0.8 \leq x_F \leq 0.96$, respectively. As for HKN07 nuclear parton distributions, the total suppression from the nuclear effects on parton distribution functions and energy loss effect is roughly 4% to 27% and 27% to 65% in the ranges $0.2 \leq x_F \leq 0.8$ and $0.8 \leq x_F \leq 0.96$, respectively. The similar results can be obtained from nDS and EKS98 nuclear parton distributions. Therefore, the energy loss effect, resulting in the suppression on $R_{W/Be}(x_F)$, is more important than the nuclear effects on parton distributions in high x_F region. Although the initial state effects on $R_{W/Be}(x_F)$ become larger as the increase of x_F , especially in high x_F region, the remained deviation from the E866 data need to be contributed by the final state effect.

After considering the initial state effects, it is supposed further that the nuclear absorption of the charm quark pair is the main final state effect. The ratios of J/ψ production

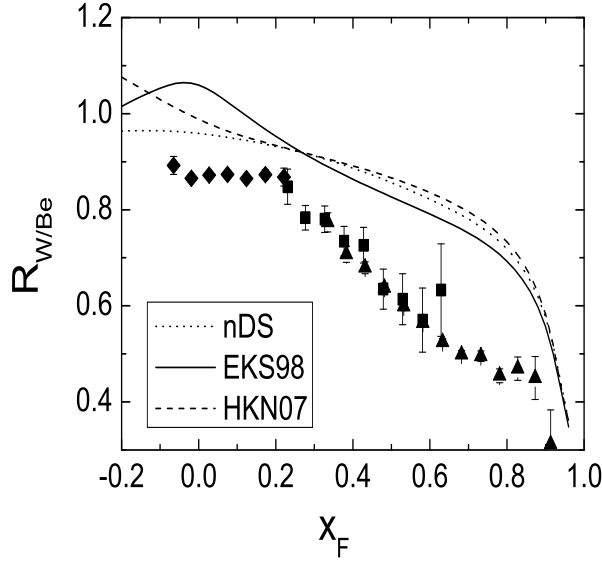


FIG. 3: The ratio $R_{W/Be}(x_F)$ by combining the nuclear effects on the parton distributions with the energy loss effect in initial state. The comments are the same as Fig.2.

TABLE I: The J/ψ -nucleon inelastic cross section $\sigma_{abs}^{J/\psi}$ and $\chi^2/d.o.f.$ in the small x_F region.

	HKN07	nDS	EKS98
$\sigma_{abs}^{J/\psi}(mb)$	2.30	2.01	3.60
$\chi^2/d.o.f.$	4.371	1.066	11.758

differential cross section $R_{W/Be}(x_F)$ are calculated in the small x_F region by combining the nuclear effects on parton distributions with the energy loss and nuclear absorption effect in the uniform framework of the Glauber model. The theoretical results are shown in Fig.4 against the E866 experimental data on $R_{W/Be}(x_F)$. The solid, dotted and dashed lines stand for the results from the EKS98, nDS and HKN07 parameterizations, respectively. The J/ψ -nucleon inelastic cross section $\sigma_{abs}^{J/\psi}$ (in unit mb) and the χ^2 per degrees of freedom are calculated and summarized in Table I by fitting the experimental data.

As can be seen in Fig.4, the E866 experimental data points show remarkably flat behavior as a function of x_F in small x_F . The covered kinematical range $-0.1 < x_F < 0.3$ correspond roughly to the parton momentum fraction $0.02 < x < 0.12$ in target nuclei. The target

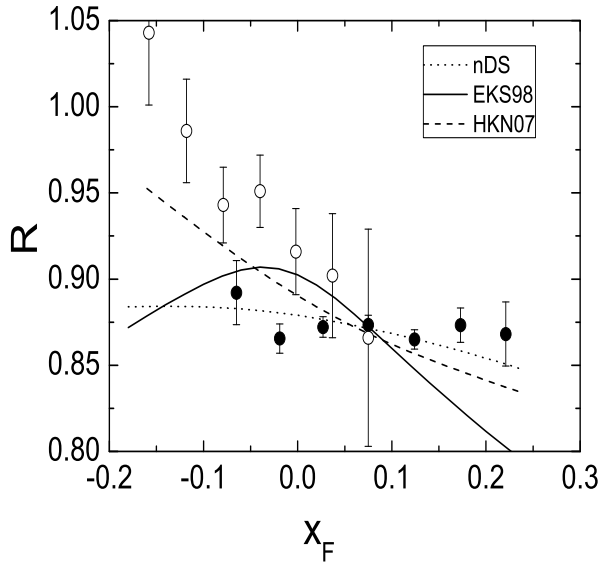


FIG. 4: The J/ψ cross section ratio $R(x_F)$. The solid circles are the ratios on tungsten to beryllium target from the E866^[4]. The open circles are the ratios on tungsten to carbon target from the HERA-B experiment^[6]. The solid, dotted and dashed lines are the calculated $R_{W/Be}(x_F)$ from the EKS98, nDS and HKN07 parameterizations by considering the initial state effects and final state nuclear absorption effect with a constant $\sigma_{abs}^{J/\psi}$.

parton momentum fraction increases as the decrease of x_F in the negative x_F region. In the range $-0.1 < x_F < 0.3$, the gluon fusion channel dominates over the $q\bar{q}$ annihilation process in J/ψ production. By compared this observation with the predictions given by the different nuclear parton distribution functions, the tendency reported by the E866 data is well reproduced by the nDS and HKN07 parameterizations in small x_F domain. These two parameterizations do not show a strong anti-shadowing effect, whereas the strong anti-shadowing presents in EKS98 nuclear gluon distribution at $x \sim 0.1$. It is shown that the E866 experimental data consequently tend to favor nDS and HKN07 sets rather than the EKS98 parameterizations. Recently, the HERA-B measurement^[6] indicates that the nuclear suppression on J/ψ production cross section ratios turns into a slight tendency towards enhancement in the negative x_F region. In Fig.4, the open circles show the ratios $R_{W/C}(x_F)$ (the Table 3 in Ref.[27]) which are derived from the HERA-B $\alpha(x_F)$ measurement (the Table 5.1 in Ref.[6]). It is apparent that the enhancement tend is only produced by HKN07

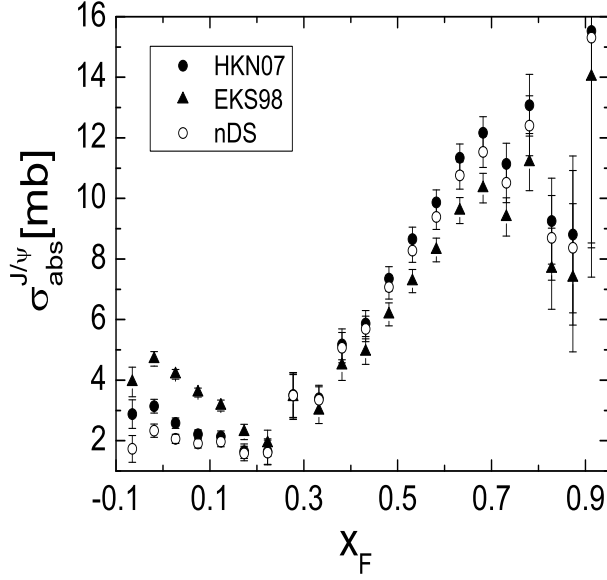


FIG. 5: The J/ψ -nucleon inelastic cross section $\sigma_{abs}^{J/\psi}$ as a function of x_F by means of HKN07(solid circles), EKS98(filled triangles) and nDS(empty circles) nuclear parton distribution functions.

parameterizations, which do not present any anti-shadowing effect. Therefore, it is concluded that the current experimental data is not in support of the anti-shadowing effect in nuclear gluon distribution. Our analysis shows similar tendency with the results in Ref.[26] in the anti-shadowing part by considering E866 measurement, but the new HERA-B data further rule out nDS nuclear gluon distribution with weak anti-shadowing effect. The paper^[26] used the color evaporation model, and investigated J/ψ production cross section ratio $R_{W/Be}(x)$ as a function of the target momentum-fraction $x(0.02 < x < 0.1)$ from E866^[4] by using the various nuclear parton distributions and keeping $\sigma_{abs}^{J/\psi}$ as a free parameter. Their result without considering HERA-B measurement is in favor of the nuclear gluon distributions which do not predict a strong anti-shadowing at $x \sim 0.1$ nor a large shadowing at small x . In detail, the E866 data agree with nDS and HKM^[14](without nuclear gluon anti-shadowing effect similar to HKN07)parameterizations, rather than the EKS98 nuclear gluon distribution. In addition, the $\sigma_{abs}^{J/\psi}$ is slight bigger than our results in Table I because of not including the energy loss effect in initial state.

The calculations on $R_{W/Be}(x_F)$ extended to the full experimental range in x_F indicate that a single value of $\sigma_{abs}^{J/\psi}$ does not provide a good agreement with the E866 experimental data.

Therefore, the J/ψ -nucleon inelastic cross section $\sigma_{abs}^{J/\psi}$ is obtained as a function of x_F by fitting the experimental data on α versus x_F . In Fig.5, The solid circles, filled triangles and empty circles correspond to the values of $\sigma_{abs}^{J/\psi}$ with based on three different nuclear parton distribution functions. In the region $0 < x_F < 0.2$, the values of $\sigma_{abs}^{J/\psi}$ given by nDS are roughly a constant because of the flat nuclear modification on gluon distribution function. However, the calculated $\sigma_{abs}^{J/\psi}$ from EKS98 have a steeper increase than those from HKN07 as the decrease of x_F , which originates from the nuclear modification on gluon distribution by EKS98 has sharply increase than that by HKN07 parameterizations in the corresponding region of the target parton momentum fraction. In the region $x_F > 0.2$, the value of $\sigma_{abs}^{J/\psi}$ comes to be larger as the increase of x_F if excluding the two values with deviating from the tendency in the range $x_F > 0.7$. With difference from the conclusion in Ref.[27], the $\sigma_{abs}^{J/\psi}$ predicted here is smaller than that without the energy loss effect in initial state in high x_F region. The results for $\sigma_{abs}^{J/\psi}$ from HKN07 nuclear parton distributions can be represented for convenience by the simple parametrization: $\sigma_{abs}^{J/\psi}(x_F) = 2.685 - 9.038x_F + 36.217x_F^2$. Therefore, it can be confirmed that $\sigma_{abs}^{J/\psi}$ depends on the kinematical variable x_F . The neglect of energy loss effect in J/ψ suppression studies is insufficient to gain an insight into the nuclear effects in J/ψ production.

IV. SUMMARY

The precise identification of J/ψ suppression mechanism as signatures of quark-gluon plasma formation requires a detailed and quantitative understanding of the nuclear effects already present in proton-nucleus collisions. The complex nuclear effects include mainly the nuclear effects of parton distribution functions and energy loss effect in initial state together with the nuclear absorption of the charm quark pair in final state. Although the nuclear effects on the parton distribution functions have been investigated by the global analysis analogous to those of the free proton, the nuclear gluon distributions have large differences between the different sets. By using the Glauber model, the energy loss of the beam proton in nuclear environment was determined well by fitting the nuclear Drell-Yan data from the Fermilab E866 experiment for 800GeV protons incident on a variety of nuclear targets^[21]. The nuclear absorption effect remained in final state can be studied with J/ψ production in 800GeV protons incident on nuclear targets. We perform a leading

order phenomenological analysis on J/ψ production cross section ratios $R_{W/Be}(x_F)$, and compare with the E866 experimental data. The different nuclear effects are obtained on the J/ψ suppression. It is shown that the energy loss effect in J/ψ suppression is more important than the nuclear effects on parton distributions in high x_F region. In the small x_F ($-0.1 < x_F < 0.3$) range, the E866 data are in agreement with nDS and HKN07 rather than the EKS98 parameterizations which give a large anti-shadowing effect. However, the new HERA-B measurement do not support the anti-shadowing effect in nuclear gluon distribution, which further rules out nDS nuclear gluon distribution. It is found that the J/ψ -nucleon inelastic cross section $\sigma_{abs}^{J/\psi}$ depends on the kinematical variable x_F , and increases as x_F in the region $x_F > 0.2$. Of course, the precise experimental data on J/ψ production will be mandatory in proton-nucleus collisions, especially in the negative x_F region. Therefore, it is desirable to operate precise measurements at J-PARC^[28] and Fermilab E906^[29] in the future.

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